



The Evaluation of End-of-Repair/End-of-Maintenance Dates for Electronic Assemblies

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Problem Description

- Electronic systems consist of multiple cards each containing multiple parts
- Many parts become obsolete long before the system support is terminated
 - Obsolete: can no longer be procured from the original vendor
- When obsolete parts are needed to repair the cards, they are drawn from inventories that may not be replenishable
- When all the parts and spare cards have been consumed, the cards may no longer be supportable

How long can legacy systems drawing from existing non-replenishable inventories of parts and cards be sustained?

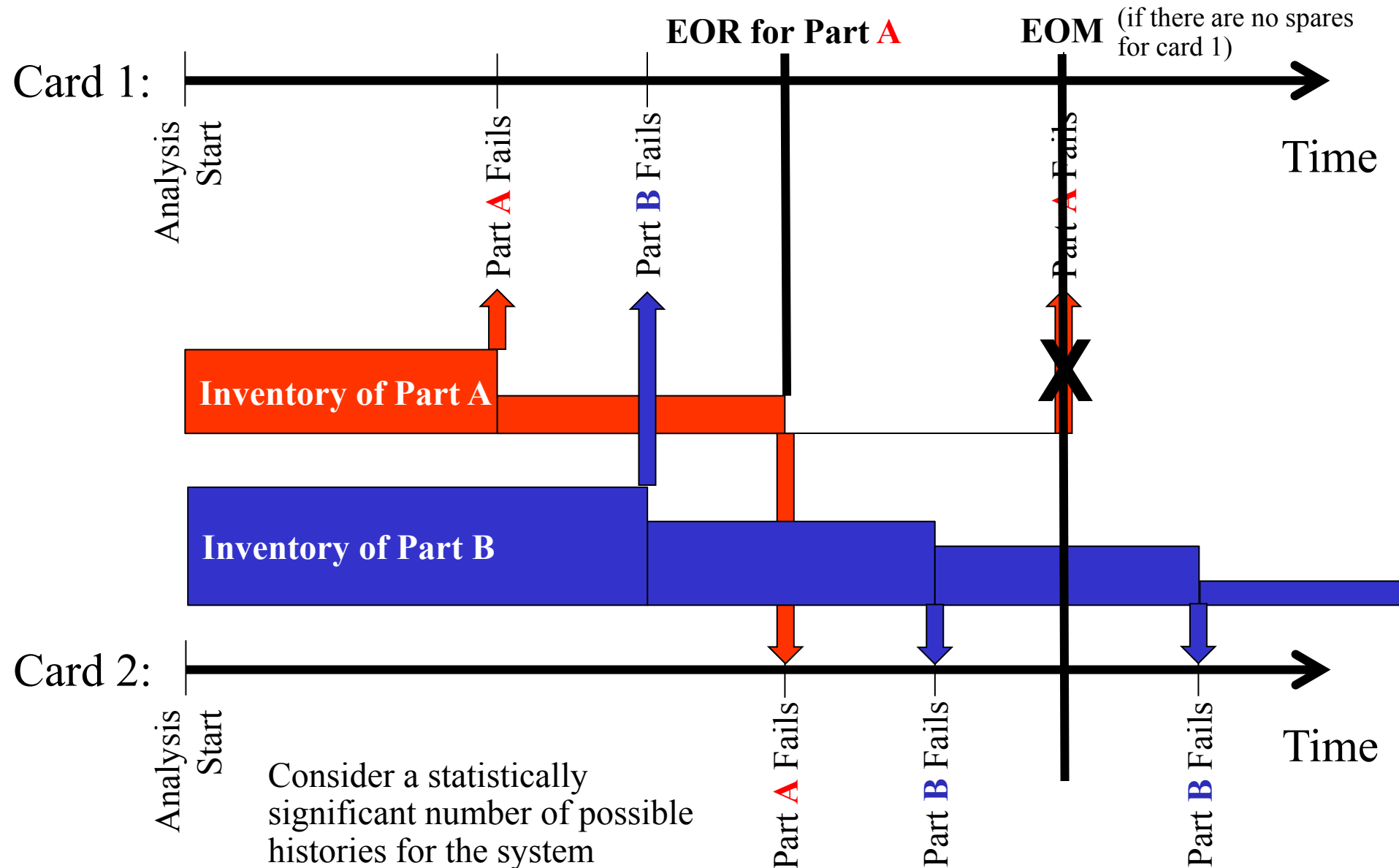
End of Repair (EOR) and End of Maintenance (EOM) Definitions

- *End of Repair (EOR)*: The date that the last repair or manufacturing action associated with a part can be successfully performed.
 - EORs are part-specific
 - EORs may be part and card specific if specific cards can only draw parts from specific inventories
- *End of Maintenance (EOM)*: The earliest date that all available inventories fail to support the demand for one or more specific parts resulting in the loss of system operation
 - EOMs are calculated for systems
 - System EOM is caused by a specific part on a specific card

Approach

- Use a stochastic discrete event simulator to track all instances of all parts in the system until repair requests cannot be fulfilled
 - Discrete event simulator: models a time line
 - Stochastic: variables can be represented using probability distributions
- Part-specific failure distributions are sampled to obtain failure dates for all parts on all cards
- When parts fail, replacements are drawn from existing inventories until the inventories are exhausted
- When the part inventories are exhausted spare cards (if any exist) are drawn until they are exhausted
- When new spare parts and cards are exhausted, parts harvested from replaced cards may optionally be drawn

Approach (continued)



Inputs and Outputs

Inputs:

- Card BOMs (Bills of Materials)
- Existing inventories of parts and cards
- Fielded systems descriptions (fielding and retirement dates, quantities, ...)
- Analysis data (start and end dates, operational hours/yr, ...)
- Observed or predicted failure data (per part per card)

Outputs:

- Probability distributions of EOM and EOR dates
- Card-specific and part-specific probabilities of being the cause of EOM and EOR
- Loss of system functionality over time

Demonstration

This demonstration analyzes the following set of cards:

Item Description	Fielded Qty	Total Depot Inventory	BOMs
SCLDU CCA	33523	363	764500-02 764500-03
SWITCH INTERFACE CCA	3573	42	203616-G07 203616-G06
VIDEO CCA	3573	79	203625-G01
LAN CCA	3625	54	207364-G07
386 MAIN CCA	3573	96	215986-G07
ANALOG MB/DB	3573	135	216103-G09 (MB/DB) 216100-G02 (DB) 215955-G09 (MB) 215955-G10 (MB) 215955-G11 (MB)
HCPU-MOD CCA	1299	56	218758-G07 763371-04 763371-05
SBIU-MOD CCA	1867	55	218759-G05 763500-04 763500-05 763500-06

Demonstration (Inputs)

Fixed Value
Uniform
Triangular
Weibull
Normal
Lognormal
Exponential
None

End of Repair (EOR) Simulator

System Load & View | Analysis | Outputs | Solution Control

Welcome | BOM Load & View | Parts Inventory Load & View

Bill of Materials Loading and Viewing

Choose card: VIDEO CCA

Part ID	Obs Stat...	Allowable Inve...	Card	Quantity	Reliability	Harvesta...	Cost
203626-002	Available	RPDB On-Han...	386 MAIN CCA	1	Fixed V...	100.0	0.0
179748-001	Available	RPDB On-Han...	ANALOG MB/DB	11	Fixed V...	100.0	0.0
179771-001	Available	RPDB On-Han...	HCPU-MOD CCA	9	Uniform	100.0	0.0
179776-001	Available	RPDB On-Han...	LAN CCA	14	Uniform	100.0	0.0
179777-001	Obsolete	RPDB On-Han...	SBIU-MOD CCA	2	Fixed V...	100.0	0.0
			SCDLU CCA	1	Uniform	100.0	0.0
			SWITCH INTERFACE CCA	5	Fixed V...	100.0	0.0
			VIDEO CCA	2	Fixed V...	100.0	0.0
				1	Uniform	100.0	0.0
				1	Fixed V...	100.0	0.0

ADD ROW (Selected)
DELETE (Selected Row)
CLEAR (All Cells)
Load New Card BOM

Available Spare Card Stock: 79

Distribution Details

179776-001

Distribution Units: Operational Hours
Cycles/Unit: Per Op Year

Distribution Type: Uniform

Range: 9.43E8

Most likely value (Mode): 4.71E8

Low Value: 0.0

High Value: 0.0

Standard Deviation: 0.0

Location Parameter: 0.0

Scale Parameter: 0.0

Shape Parameter: 0.0

Fixed Value: 0.0

Use failures to date? ☒ Yes?

OK Cancel Help

Demonstration (Inputs)

End of Repair (EOR) Simulator

System Load & View Analysis Outputs Solution Control

Welcome BOM Load & View Parts Inventory Load & View

Parts Inventory Loading and Viewing

Maximum Allowable Inventories: 5

Part ID	RPDB O...	Harvest					Total
016026-...	5000	350					5350
016073-...	1601	840					2441
063080-...	302	20					322
115000-...	87	20					107
116002-...	145	20					165
119562-...	980	20					1000
119563-...	16	10					26
119605-...	250	70					320
125901-...	0	0					0
492153-...	48	50					98

ADD COLUMN
(To Right of Selected)

DELETE
(Selected Column)

CLEAR
(All Cells)

Load New Inventory

Analysis date to EOM date
2166.48

Pause

Demonstration (Inputs)

The screenshot displays the 'End of Repair (EOR) Simulator' window. The interface includes a menu bar with 'System Load & View', 'Analysis', 'Outputs', and 'Solution Control'. Below the menu bar are three tabs: 'Welcome', 'BOM Load & View', and 'Parts Inventory Load & View'. The main content area is titled 'Systems Loading and Viewing' and indicates a 'Maximum Allowable Systems: 6'. A table lists various systems with their Card IDs, VSCS System numbers, and Total counts. Below the table are four buttons: 'ADD COLUMN (To Right of Selected)', 'DELETE (Selected Column)', 'CLEAR (All Cells)', and 'Load New System'.

Card ID	VSCS System						Total
SWITCH INTERFA...	3573						3573
VIDEO CCA	3573						3573
LAN CCA	3625						3625
386 MAIN CCA	3573						3573
ANALOG MB/DB	3573						3573
HCPU-MOD CCA	1299						1299
SBIU-MOD CCA	1867						1867
SCDLU CCA	33523						33523

Buttons:

- ADD COLUMN (To Right of Selected)
- DELETE (Selected Column)
- CLEAR (All Cells)
- Load New System

Demonstration (Inputs)

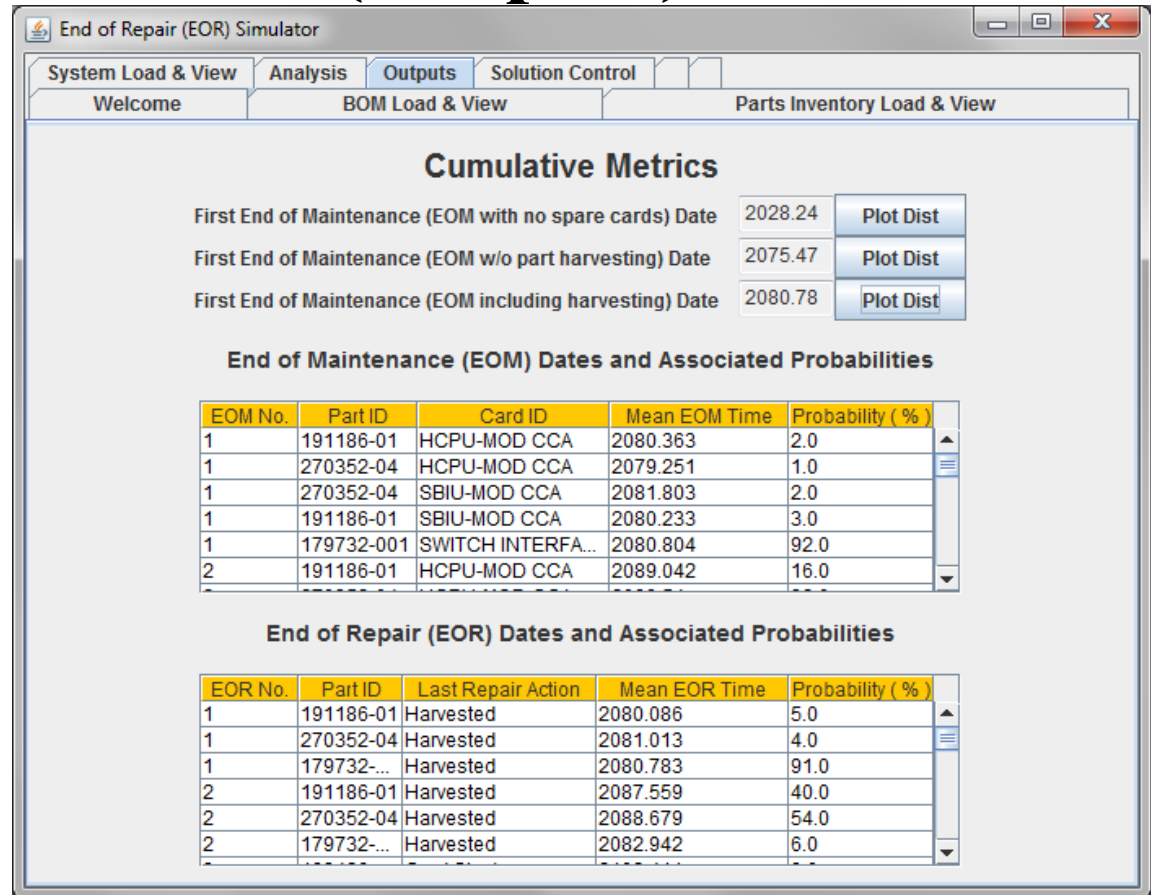
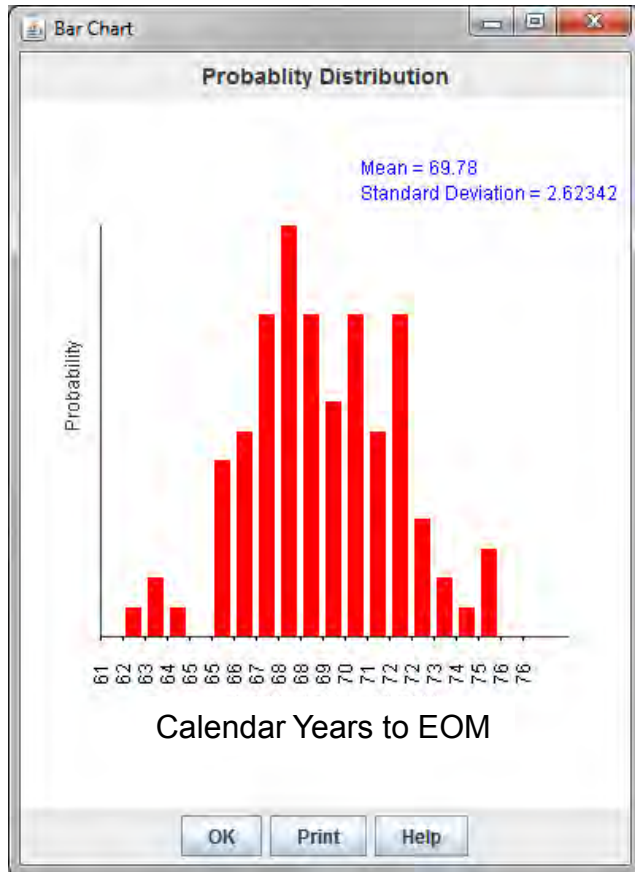
The screenshot displays the 'End of Repair (EOR) Simulator' window. The interface includes a top menu bar with 'System Load & View', 'Analysis', 'Outputs', and 'Solution Control'. Below this is a sub-menu bar with 'Welcome', 'BOM Load & View', and 'Parts Inventory Load & View'. The main content area is titled 'Analysis Inputs' and contains three input fields: 'Starting date for failure data' with the value '1993.16', 'Analysis start date' with the value '2011.0', and 'Operational hours per year' with the value '8760.0'. At the bottom of the window, there is a row of five buttons: 'Solution Control', 'Save Field States', 'Load', 'Default Inputs', and 'Restore Inventories'.

Analysis Inputs	
Starting date for failure data	1993.16
Analysis start date	2011.0
Operational hours per year	8760.0

This is a Large “Bookkeeping” Problem

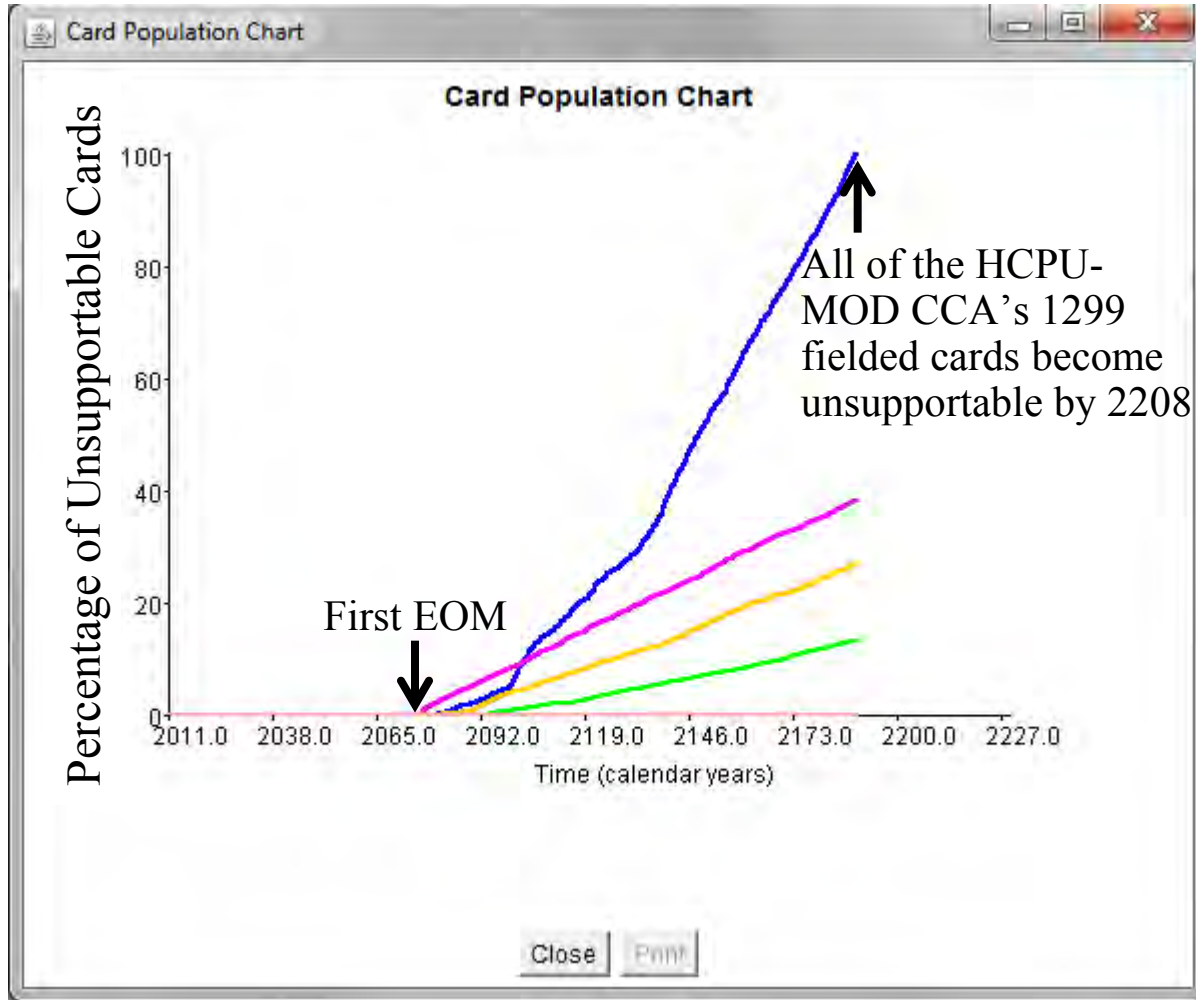
- Every instance of every part on every board is effectively modeled independently
 - Multiple instances of parts on cards accounted for
 - Multiple instances of cards in systems accounted for
 - Multiple systems can be included
- This 8-card example:
 - Tracks 13,860,186 independent parts life history
 - Then we track at least 1000 system life histories to construct probability distributions
 - Takes about 100 min to run 1000 system life histories for the 8 board system

Demonstration (Outputs)



- Part 179732-001 causes the first EOM 92% of the time--card statistics below regard the first EOM
- SWITCH INTERFACE CCA is the card that can't be supported 92% of the time
- SBIU-MOD CCA is the card that can't be supported 5% of the time
- HCPU-MOD CCA is the card that can't be supported 3% of the time

Demonstration (Outputs)



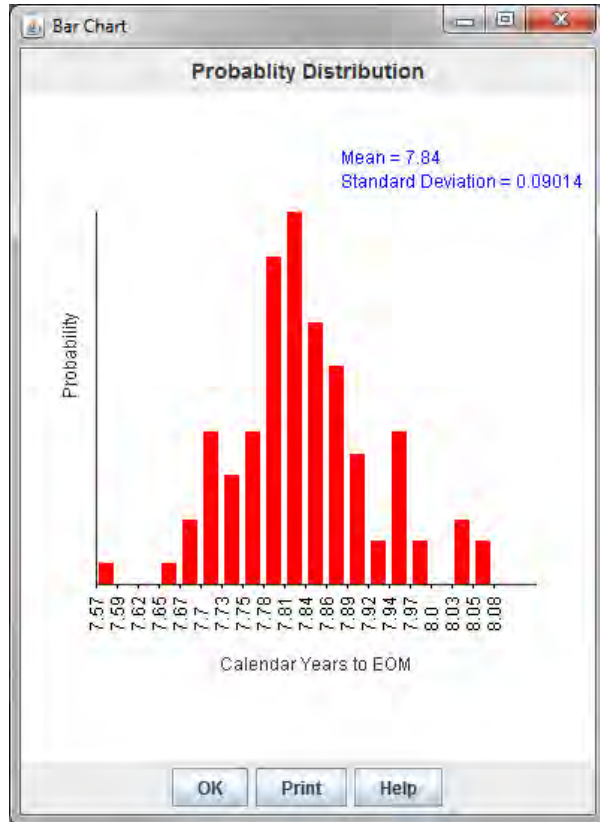
In 2208 (end of simulation):

CCA	Number of Unsupportable Cards
386 MAIN CCA (Green)	495
ANALOG MB/DB (Red)	0
HCPU-MOD CCA (Blue)	1299
LAN CCA (Black)	0
SBIU-MOD CCA (Orange)	506
SCLDU CCA (Cyan)	0
SWCH INT. CCA (Magenta)	1325
VIDEO CCA (Pink)	0

Yes, dates (200+ years) are unrealistic. This is because this is an abbreviated 8 card example drawing from an inventory that supports a larger card set.

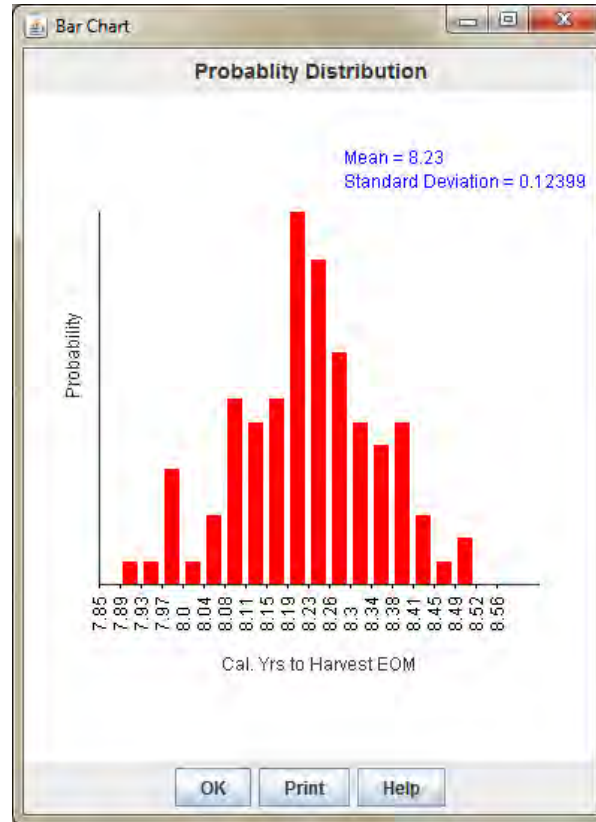
Demonstration – 78 Card System

No Harvesting



7.57-8.08 years to EOM

Harvested Parts from Scrapped Assemblies



7.85-8.56 years to EOM, gain ~0.5 year by harvesting

Key Assumptions:

- Existing inventories are not replenished
- Obsolete parts are not available from other sources
- Observed failure history is a good predictor of future sparing needs

Model Features

(Currently Supported)

- Multiple (segregated) inventories of new parts
- Cards can have spare inventories too
- Operates from failure distributions (user can define failure distributions)
- Part failure distributions can be card specific
- Synthesizing distributions from observed failures to date
- Shelf life (and other degradation in inventories)

But

There are lots of remaining problems that complicate this solution, including:

- Non-standard parts (we only treat standard parts today)
- Concurrent cost calculations
- How should parts with no failure history be treated?
- Replenishment of inventories via aftermarket sources
- Dependencies between parts, in some cases parts have to be replaced in groups (also “shot gunning”)

Summary

Quantitative (simulation-based) analysis of:

- The length of time that legacy inventories can be used to support an existing system
- Loss of support of a system over time

The analysis can also be reversed and used to forecast lifetime buy quantities (and associated confidence levels)